The snuffbox technique: A reliable color Doppler method to assess hand circulation

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Objective: Although the Allen test is crude and subjective, an objective color Doppler method has yet to be established in the assessment of hand circulation before radial artery harvesting. Doppler studies so far have neglected the Doppler principle that the insonation angles should be less than 30° and have not been compared with any standard except the crude Allen test. We therefore introduced the snuffbox technique, measuring the radial artery at the anatomic snuffbox, which is the most distal area after harvesting. Color Doppler methods were compared with the stump pressure as a criterion standard.

Methods: Maximal flow velocity and Doppler angles of the snuffbox, palmar artery, and ulnar artery were measured in 20 hands before and after radial artery harvesting. Stump pressure was measured during surgery.

Results: Maximal flow velocity in the snuffbox decreased with radial artery compression and after radial artery harvesting. All the flow patterns in the snuffbox technique showed simultaneous reversal. Maximal flow velocity in the ulnar artery increased with radial artery compression and after radial artery harvesting. Maximal flow velocity in the palmar artery did not change significantly with radial artery compression or after radial artery harvesting. Doppler angles were 20.9° ± 6.0° in the radial artery of the snuffbox, 82.5° ± 6.1° at the palmar artery, and 81.0° ± 7.6° at the ulnar artery. The changes in the snuffbox technique were highly correlated with the stump pressure ratio ($P < .001$).

Conclusions: Among various color Doppler methods, the snuffbox technique was precise and reliable.

Digital ischemia is a potentially serious complication after radial artery (RA) harvesting.[1,2] The Allen test is traditional and crude[3,4] but is still used as a simple and cost-effective test.[3-6] Many studies have agreed on the high correlation between the Allen test and color Doppler methods that are expected to be more objective, quantitative, and reproducible.[7-13] The Doppler flow changes of the ulnar artery (UA) or palmar artery (PA) were used as alternative screening methods. However, none of these studies mentioned the Doppler technologic principle that the insonation angles should be less than 30° to discuss the flow velocity and its changes.[7-12] We therefore introduced the snuffbox technique as a new color Doppler method.[13] The RA in the anatomic snuffbox runs between the first metacarpal bone and the second carpal bone from the dorsal side to the palmar side. The insonation angle is anatomically less than 30° from the object to the probe, and the RA in the snuffbox becomes the most distal UA territory after RA harvesting. The aims of this study were as follows: (1) to compare the Doppler data derived from the snuffbox technique, UA study, and PA study with the distal surgical stump pressure of the RA as a criterion standard; (2) to indicate the Doppler

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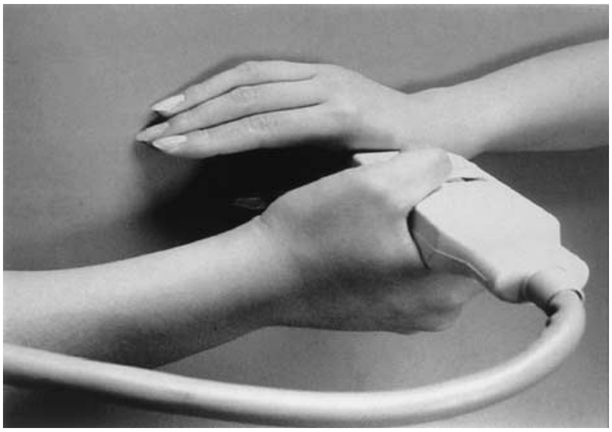

Figure 1. Snuffbox technique. Probe is placed at anatomic snuffbox.

insonation angle among the Doppler studies; and (3) to discuss the relative efficacy of the snuffbox technique among color Doppler methods.

Material and Methods

Twenty nondominant hands, with negative Allen test results, in 20 patients (15 men and 5 women, mean age 68.0 ± 7.9 years) scheduled for coronary artery bypass grafting were examined in 2001. Informed consent was obtained from each patient. The study was approved by the ethical committee of Hiroshima University Hospital.

The modified Allen test was performed as follows.[3-5] The hand was supinated. The examiner detected the UA and RA pulsation and placed a thumb lightly on the UA and RA at the wrist to compress and release them correctly. The hand was closed firmly to evacuate the capillary color. The RA and UA were compressed, and the patient clenched and opened the fist mutually 10 times, then relaxing the hand completely. The examiner released the UA and observed the color of the hand and fingers. The recovery time was recorded.

The patient sat on a comfortable sofa in a surgical laboratory unit in which the temperature was maintained between 21°C and 25°C. The arm was placed in the supine position on a desk. The maximal flow velocity (V_{max}) values of the RA in the snuffbox, the UA at the wrist, and the superficial PA were measured with the color Doppler mode with a 7.5-MHz echocardiographic system (PLF-703NT, Sonolayer SSA-260A; Toshiba Corporation Medical Systems Company, Tokyo, Japan). The appropriate site to place the probe could be determined by feeling the RA pulsation in the snuffbox between the tendons of the extensor pollicis. The sampling volume was adjusted to the most distal RA (Figure 1). Detection of the PA was mainly by ultrasonographic scanning. UA pulsation was felt above the flexor retinaculum. The sampling volume was placed to the target with the insonation angle adjusted as longitudinal as possible. V_{max} values were measured without RA compression before surgery, with RA compression before surgery, and at 2 weeks after RA harvesting. V_{max} values were measured when the Doppler signals were apparently clear, and the sampling volume was placed where no stenotic arterial lesion was evident.

Stump Pressure

The RA was harvested in the usual manner. After division of the conduit, a 21-gauge cannula was inserted into the distal end of the RA and connected to a pressure monitor. The maximal pressure of the stump and the ipsilateral RA pressure were recorded simultaneously. The ratio between the stump pressure and the contralateral radial pressure was defined as the stump ratio.

Calculation and Statistical Analysis

Results are expressed as mean ± SD. Linear correlation analysis and the Mann-Whitney *U* test were performed with statistical software (StatView version 5.0J; SAS Institute, Inc, Cary, NC).

Results

No hand ischemia was encountered during or after the operation in any patient in this series. There were no significant differences between the harvesting hand and the contralateral hand in the V_{max} values of the snuffbox, PA, or UA (Table 1). The V_{max} in the snuffbox was 34.1 ± 10.0 cm/s without RA compression, −22.3 ± −10.1 cm/s with compression, and −23.2 ± −9.0 cm/s after harvesting. All the flow patterns in the snuffbox technique showed reversal with RA compression after harvesting. V_{max} values in the PA were 49.5 ± 17.2 cm/s without RA compression, 49.2 ± 23.0 cm/s with compression, and 49.6 ± 21.8 cm/s after harvesting. V_{max} values in the UA were 55.0 ± 22.6 cm/s without RA compression, 64.1 ± 26.5 cm/s with compression, and 61.4 ± 21.7 cm/s after harvesting. Doppler angles were 20.9° ± 5.0° (95% confidence interval 18.6°-23.2°) in the snuffbox technique, 82.5° ± 6.1° (95% confidence interval 79.6°-85.3°) at the PA, and 81.0° ± 7.6° (95% confidence interval 77.4°-84.6°) at the UA. During surgery the stump pressure was 77 ± 32 mm Hg. The simultaneous contralateral RA pressure was 107 ± 16 mm Hg. The stump pressure ratio was 0.70 ± 0.25. The preoperative V_{max} values without RA compression were normalized and calculated as the V_{max} ratios before harvesting and after harvesting. The stump pressure ratio was compared with the recovery time in the Allen test and the V_{max} ratio (Table 2). The recovery time in the Allen test was significantly correlated with the stump pressure ratio ($r = 0.565$, $P = .009$; Table 3). The changes of the V_{max} values in the PA and UA were not correlated with the stump pressure ratio. The flow velocity changes in the snuffbox technique were highly correlated with the stump pressure ratio ($r = 0.931$, $P < .001$ with RA compression, $r = 0.844$, $P < .001$ after harvesting).

Discussion

The Allen test is the most frequently used screening method in RA harvesting. Most surgeons still rely on this test and

TABLE 1. Difference between the harvesting hand and the contralateral hand

	Harvesting side		Contralateral side		
V_{max} (cm/s)	Mean ± SD	95% Confidence interval	Mean ± SD	95% Confidence interval	*P* value
RA in the snuffbox	34.1 ± 10.0	29.4-38.8	34.0 ± 9.3	29.5-38.7	.884
PA	49.5 ± 17.2	41.4-57.5	49.8 ± 17.1	41.3-58.3	.930
UA	55.0 ± 22.6	44.4-65.6	58.8 ± 23.2	47.3-70.3	.589

TABLE 2. V_{max} in the snuffbox, the PA, and the UA

	Without compression before harvesting		With compression before harvesting		After harvesting	
	Mean ± SD	95% Confidence interval	Mean ± SD	95% Confidence interval	Mean ± SD	95% Confidence interval
RA in snuffbox	34.1 ± 10.0	29.4-38.8	−22.3 ± −10.1	−27.0 to −17.5	−23.2 ± −9.0	−27.3 to 19.0
PA	49.5 ± 17.2	41.4-57.5	49.2 ± 23.0	38.4-60.0	49.6 ± 21.8	39.4-59.7
UA	55.0 ± 22.6	44.4-65.6	64.1 ± 26.5	51.7-76.5	61.4 ± 21.7	51.2-71.5

Values are in centimeters per second.

TABLE 3. The correlation coefficients between the stump pressure ratio and measurements

	Mean ± SD	95% Confidence interval	Correlation coefficient to stump pressure ratio	*P* value
Allen test (s)	4.5 ± 2.0	3.7-5.8	0.565	.009
Preharvesting ratio				
Snuffbox technique	0.66 ± 0.24	0.54-0.77	0.931	<.001
PA	0.95 ± 0.27	0.83-1.10	0.135	.570
UA	1.24 ± 0.24	1.12-1.35	0.006	.981
Postharvesting ratio				
Snuffbox technique	0.70 ± 0.25	0.58-0.81	0.844	<.001
PA	0.98 ± 0.20	0.89-1.08	0.223	.344
UA	1.17 ± 0.26	1.06-1.29	0.100	.676

Preharvesting ratio was V_{max} with RA compression/V_{max} without RA compression; postharvesting ratio was V_{max} after RA harvesting/V_{max} without RA compression; stump pressure ratio was stump pressure/RA pressure in the contralateral side.

may use it before surgery. Our study did demonstrate that the Allen test results were highly correlated with the criterion standard of stump pressure ratio. However, there have been several reports regarding digital ischemia after RA harvesting.[1,2] In these reports, the preoperative Allen test was performed, and the results were all negative. This evidence has demonstrated that a more objective record is needed before surgery. Once an ischemic event takes place, no concrete or objective record remains of the Allen test. In addition to the possible social and legal consequences after the ischemic event, the assessment of hand circulation is essential in case of a shortage of other conduits. If a patient with severe diabetes has no venous conduits because of varicose veins or postharvesting status, an internal thoracic artery and the RAs may be preferred. But if his or her Allen test result is longer than 5 seconds, the surgeon needs to confirm the safety of the RA harvesting and to decide before the operation whether to harvest the RAs, to alter the conduits, or to skeletonize the internal thoracic arteries.

Color Doppler methods are expected to be more reliable and objective than the Allen test.[7-12] The UL and PA are the primary measurements. Although various studies have demonstrated that these Doppler methods are as good as the Allen test, there is no evidence that they are more effective than the Allen test. Such studies so far have had three major problems to be solved. First, the principle of Doppler technology that the Doppler insonation angle should be less than 30° was neglected in those studies in which Doppler velocities were analyzed and discussed. An insonation angle of less than 30° is required if the velocity is to be analyzed. In our examinations the insonation angles of the UA and PA to the probe were more than 80°. This demonstrates that the

Doppler examinations of the UA and PA may be limited for evaluating the relative flow change. Moreover, the absolute values of the flow velocity may not be accurate in UA and PA studies. Second, the anatomic positions of the probe in the UA and PA studies do not reflect the postoperative hand circulation. A recent cadaver study from the Austin Hospital in Melbourne reported the intrinsic circulation of the hand.[14] This anatomic study confirmed the presence of a collateral supply from the UA system to the RA, but the anastomoses between the superficial and the deep palmar arch are complex and varied. This demonstrated that even if the Doppler velocities of the UA and PA are increased after RA compression in the preoperative assessment, ischemia may nevertheless occur after RA harvesting. Third, in those studies that aimed to demonstrate the efficacy of Doppler examination, Doppler-derived data were compared with the Allen test as a standard and were simply proved to be highly correlated with this traditional method.[5,7,8] Evidence of a high correlation between the new methods and the Allen test may not be enough to prove the efficacy and reliability of the color Doppler methods, because the Allen test is already known to be crude and subjective.

We therefore introduced the snuffbox technique as a new color Doppler method.[13] The RA in the anatomic snuffbox is located next to the surgical stump after RA harvesting and becomes the most distal and peripheral portion after alteration of the blood supply system after RA harvesting. The findings of the blood flow with RA compression before harvesting may demonstrate and predict postoperative hand ischemia. The advantages of this technique are as follows. First, the Doppler insonation angles from the probe to the target RA are less than 30°. This insonation angle is more reasonable and acceptable, in accordance with the principle of Doppler technology. The flow velocity data can thus be discussed not only relatively but also absolutely. Second, the blood flow direction changes immediately after RA compression and RA harvesting. This quick qualitative sign may be useful in routine clinical business. Third, the most important evidence of this report is that the snuffbox technique is highly correlated with the changes in the stump pressure. We consider the stump pressure to be the criterion standard because it demonstrates the most practical and reliable information regarding hand circulation after RA harvesting. We therefore believe that the snuffbox technique is the most reliable and precise color Doppler method because of the high correlation between the changes in stump pressure and the V_{max} of the snuffbox technique.

Two limitations should be mentioned. One is a minor anatomic limitation. Although anatomic reports and figures confirm an anatomic connection between the RA and UA through the palmar arch,[14-17] Ruengsakulrach and colleagues[13] reported the existence of a median artery in 6% of study cadavers, arising from the UA or RA above the wrist and implying another collateral supply to the hand after RA harvesting. If this rare artery terminates at the level of the wrist just distal to the compression point, the reversal flow sign with RA compression before harvesting might not be available because of normograde flow through the median arterial blood supply. Even in this situation, however, the snuffbox technique is valuable because the absolute values of the flow velocity can be discussed.

The other limitation is the difficulty of demonstrating operative safety in this study. The final goal of this study was to create more sophisticated criteria to avoid hand ischemia as a result of RA harvesting. Since April 2002, we have been harvesting RAs according to only the information from the snuffbox technique. The results of the Allen test are blinded until later analysis. We will report on the operative safety of the snuffbox technique in a future article.

Nine months after our initial report, Yokoyama and colleagues[18] reported the feasibility of color Doppler evaluation of the hand circulation in a series of transradial coronary interventions. They also mentioned the advantages of the reversal flow sign with RA compression in the distal RA. We hope that the snuffbox technique will prevail as an alternative standard to the Allen test, not only in the field of cardiac surgery but also for cardiologists and anesthesiologists who use the RA.

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